Cloud Top Properties: Challenges in Extending MODIS to VIIRS

Bryan A. Baum[1], W. Paul Menzel[1], Ray Garcia[1], Eva Schiffer[1]
Irina Gladkova[2] and Fazlul Shahriar[2]
Andrew Heidinger[3]

[1]Space Science and Engineering Center, University of Wisconsin-Madison
[2]City College of New York
[3]NOAA/NESDIS/STAR, UW-Madison

Main topics:

Brief report on 1ST International Cloud Working Group

Construction of 13.3-μm channel based on VIIRS & CrIS data fusion

Development & application of new Level-3 gridding software

Cloud top heights derived with/without fusion channel

Joint MODIS-Suomi NPP Science Team Meeting
June 2016

The 1st International Cloud Working Group

Hosted by Jerome Riedi in Lille, France in May 2016

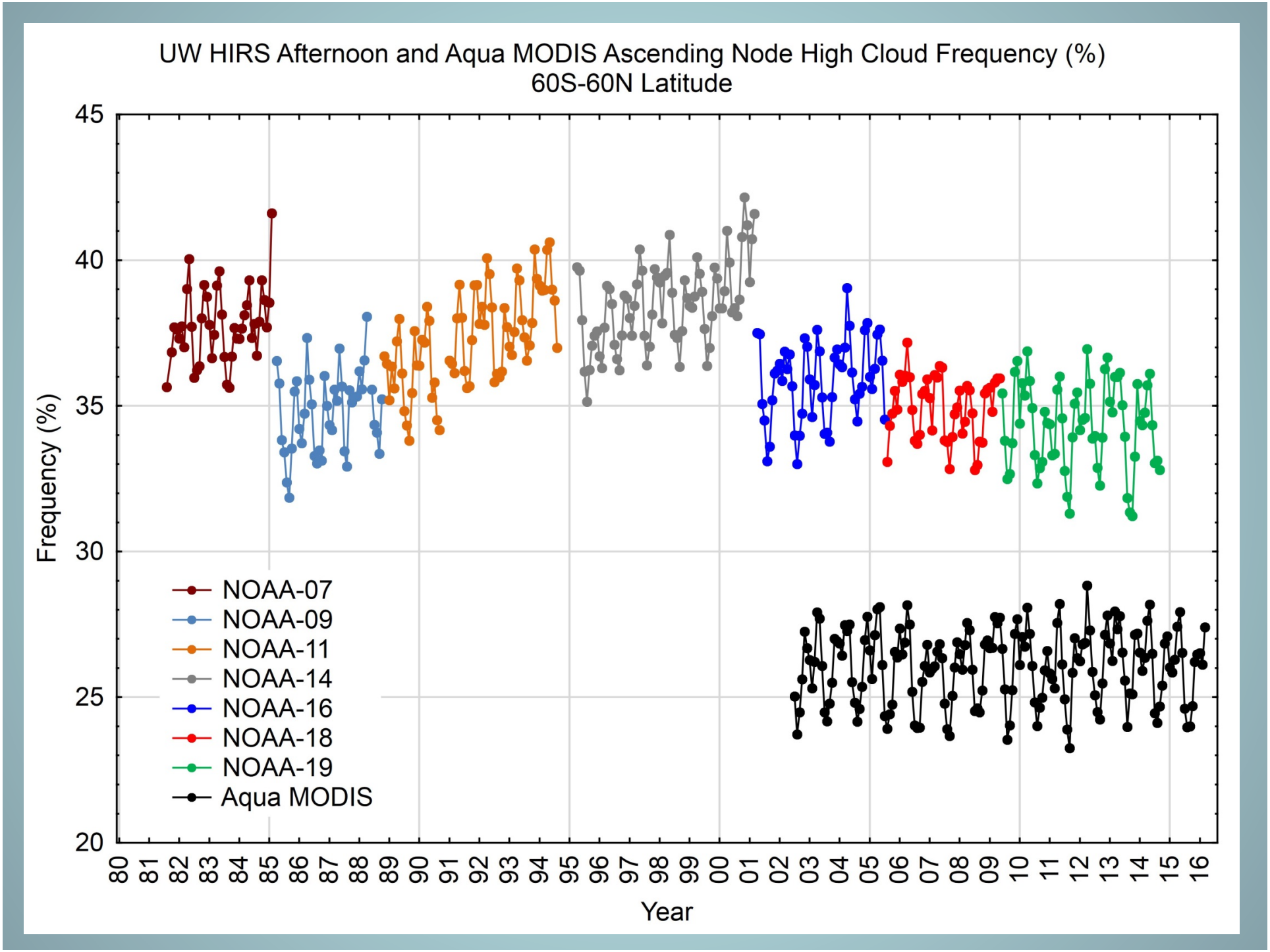
http://www-loa.univ-lille1.fr/workshops/ICWG2016

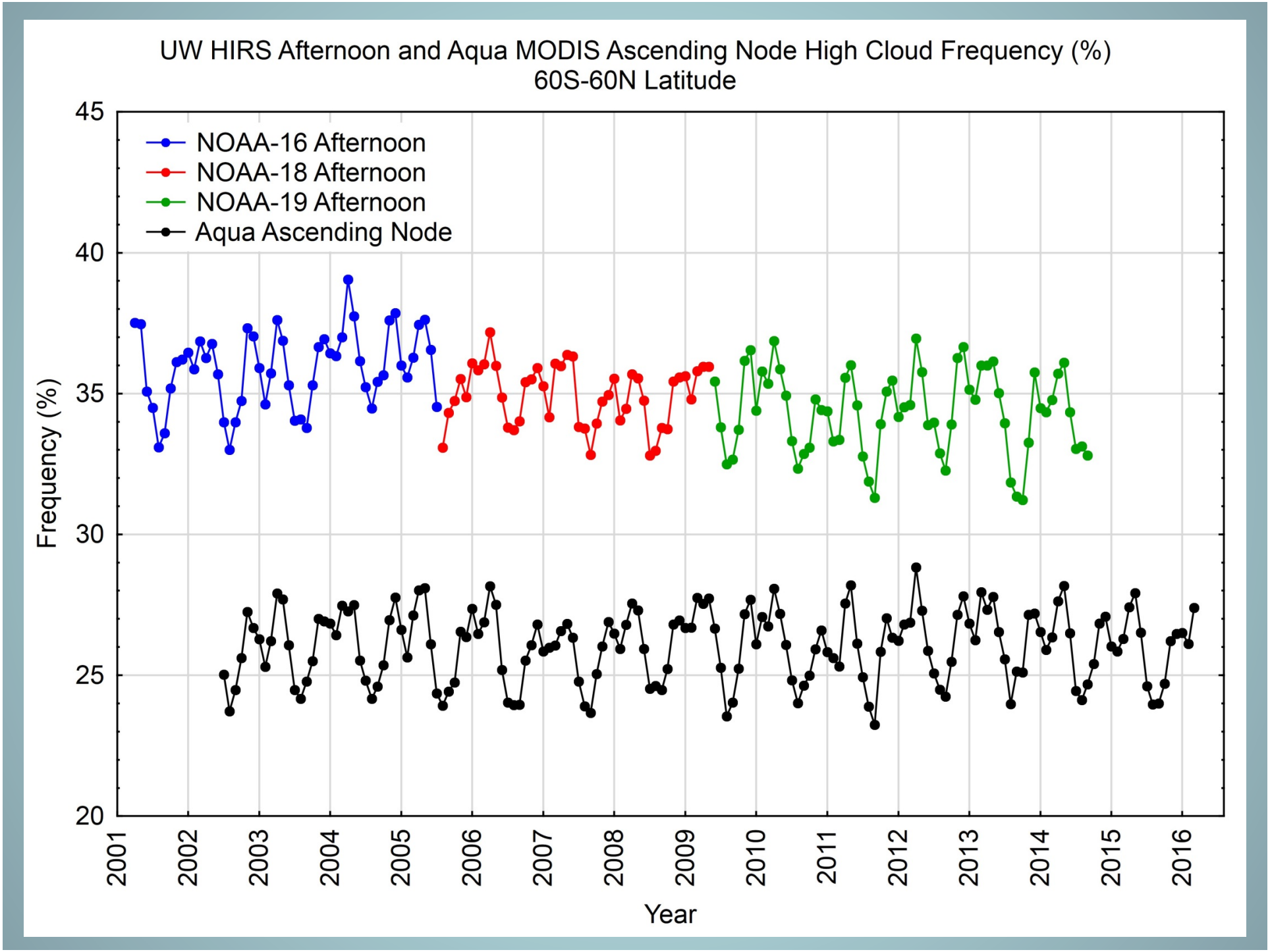
Topical Groups

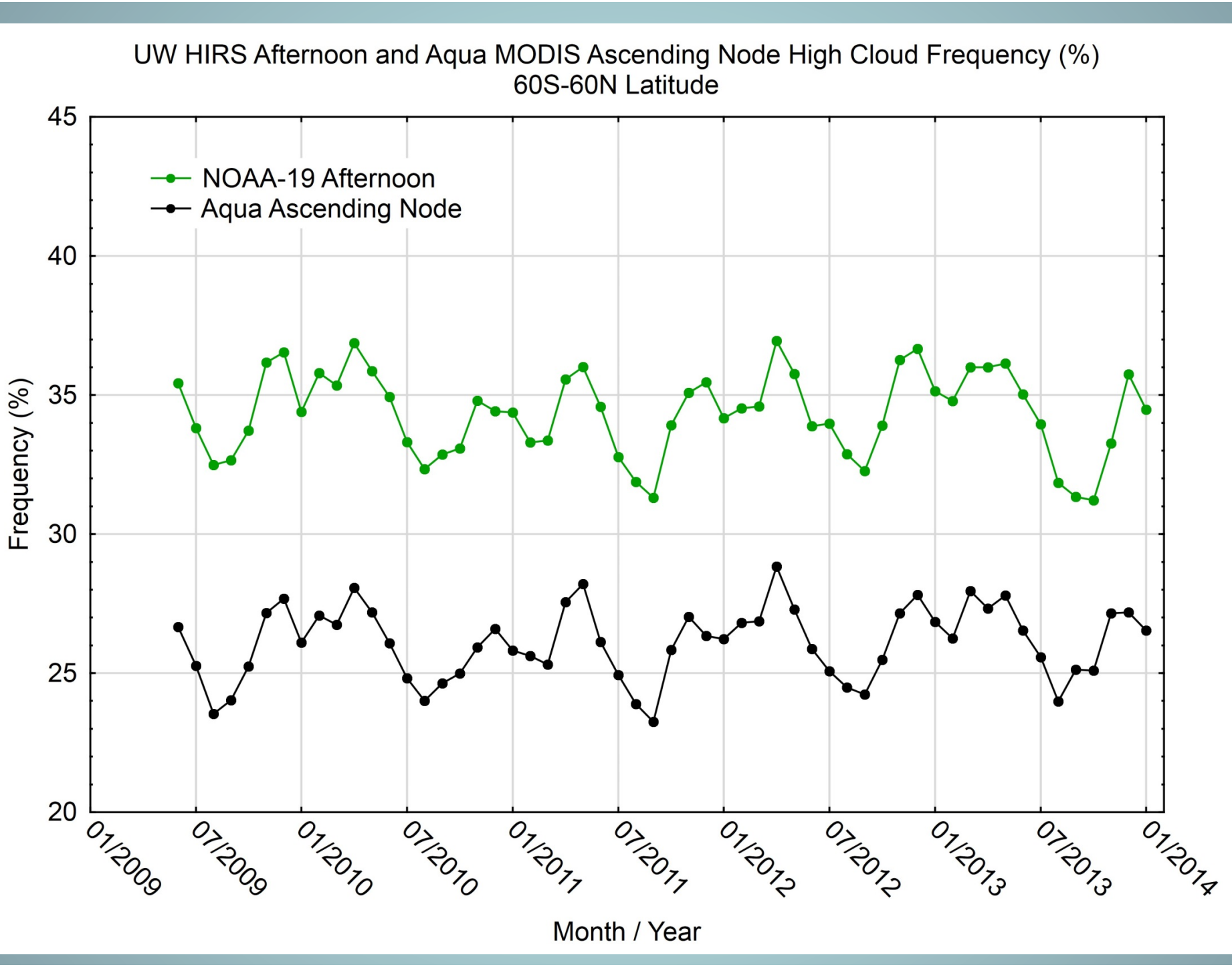
- Severe weather & nowcasting applications
- Cloud and aerosol masking
- Cloud models for remote sensing
- Assessment of cloud climate data records
- Retrieval uncertainties
- Intercomparison of Level-2 cloud parameters
- Critical contribution of spaceborne active sensors for validation

Cloud parameter comparison effort is important and needs agency attention

2nd GEWEX cloud climatology assessment is being initiated

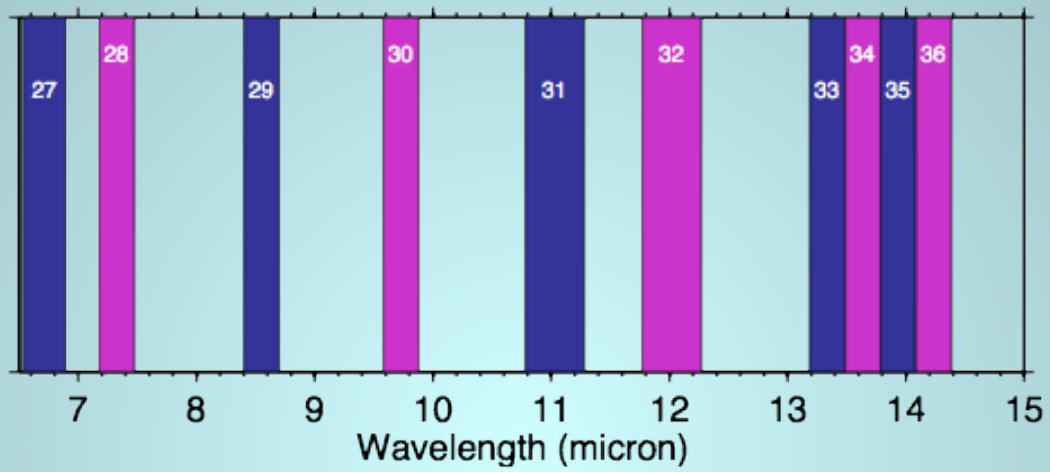

UW HIRS Afternoon and Aqua MODIS Ascending Node High Cloud Frequency (%)
60S-60N Latitude
Frequency (%)
45
40
35
30
25
20
80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16
Year
NOAA-07
NOAA-09
NOAA-11
NOAA-14
NOAA-16
NOAA-18
NOAA-19
Aqua MODIS


UW HIRS Afternoon and Aqua MODIS Ascending Node High Cloud Frequency (%)
60S-60N Latitude
NOAA-16 Afternoon
NOAA-18 Afternoon
NOAA-19 Afternoon
Aqua Ascending Node
Frequency (%)
45
40
35
30
25
20
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
Year

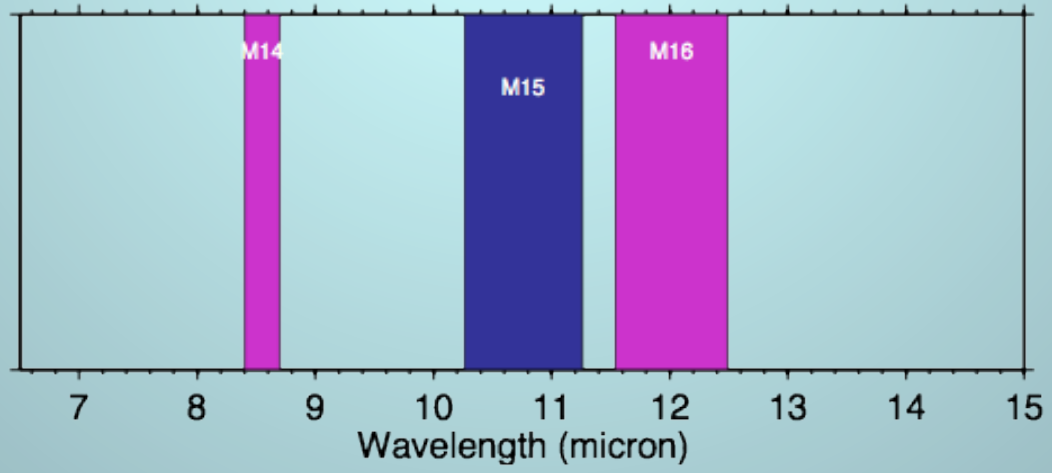

UW HIRS Afternoon and Aqua MODIS Ascending Node High Cloud Frequency (%)
60S-60N Latitude
NOAA-19 Afternoon
Aqua Ascending Node
Frequency (%)
45
40
35
30
25
20
01/2009
07/2009
01/2010
07/2010
01/2011
07/2011
01/2012
07/2012
01/2013
07/2013
01/2014
Month / Year

VIIRS and MODIS IR spectral bands

MODIS



VIIRS: M bands



Different Approaches to Linking Imager and Sounder

Approach 1: Perform analysis for sounder FOV as first step

- Use CTP from sounder as first guess for imager-based optimal estimation

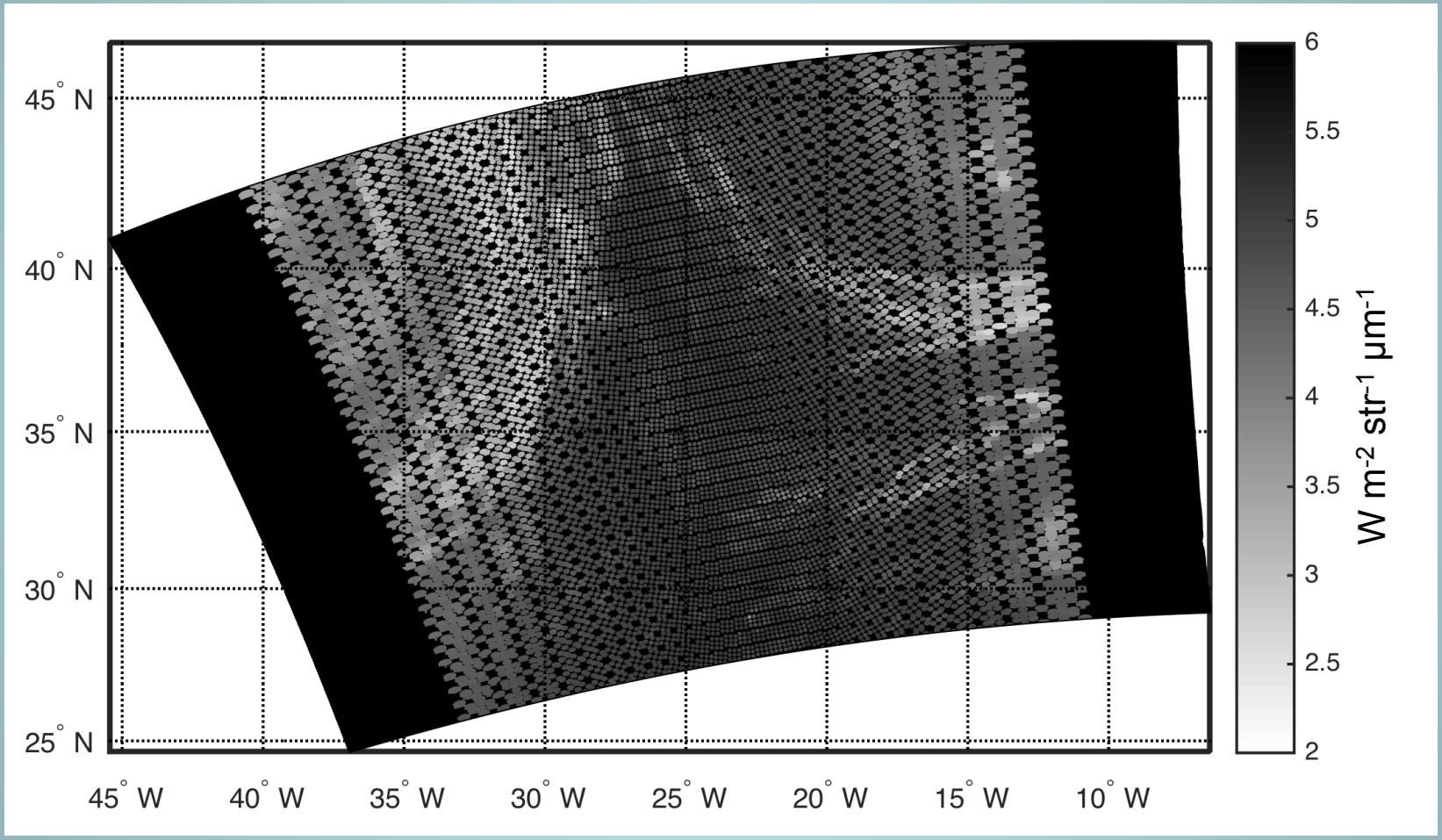
Approach 2: *Data fusion statistical approach to construct 13.3 μm at imager resolution*

- *Use combination of IR window and 13.3-μm channels in optimal estimation*

Potential application to other polar-orbiting platforms

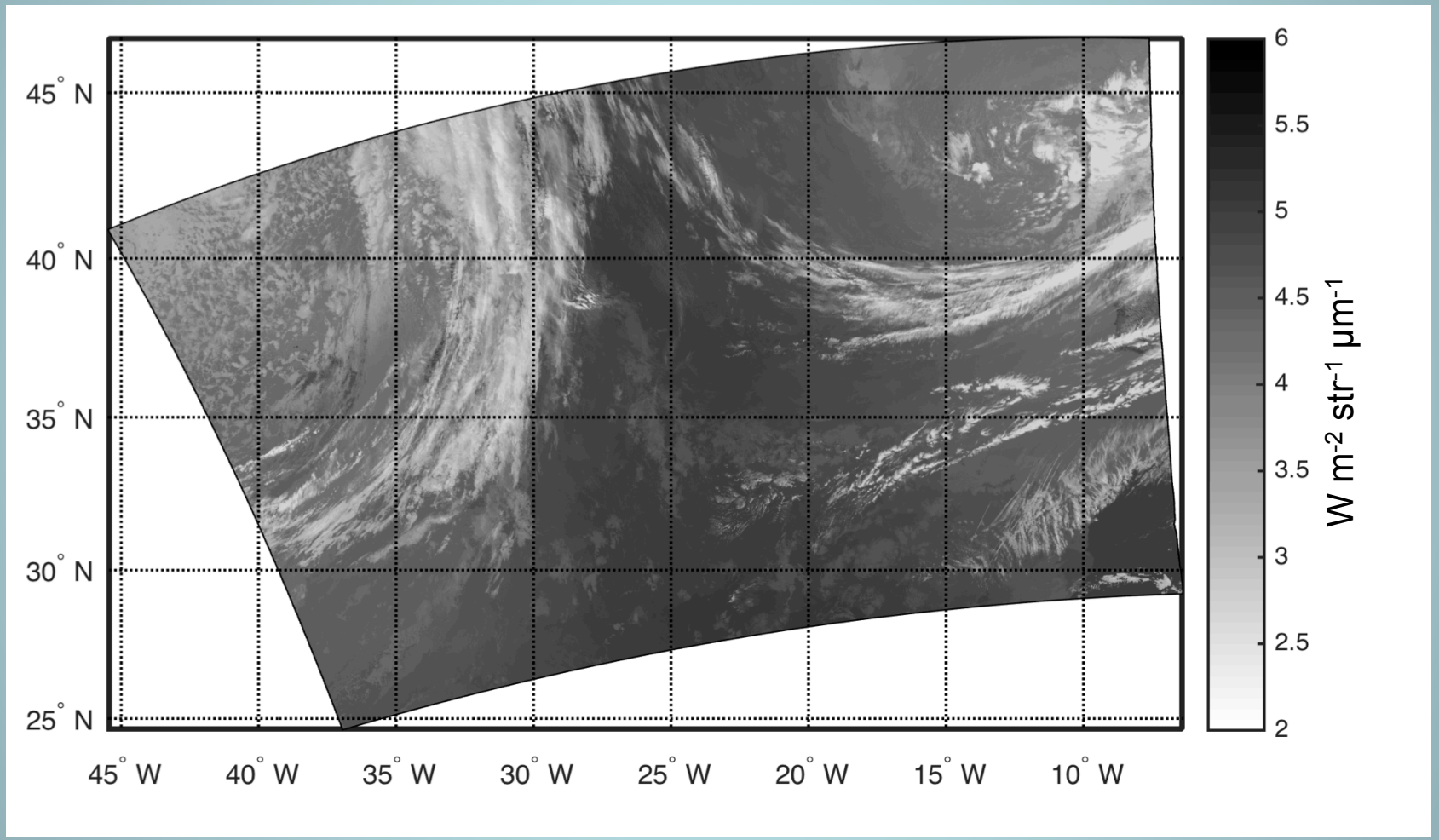
Sensor	Swath Width (km)
AVHRR › NOAA	2800
HIRS	2200
MODIS › Aqua	2330
AIRS	1650
VIIRS › S-NPP	3040
CrIS	2200
AVHRR › Metop-A/B	2800
HIRS/IASI	2200

CrIS FOVs Superimposed on VIIRS Swath



Scene over eastern Atlantic Ocean on April 17, 2015 at 1440 UTC

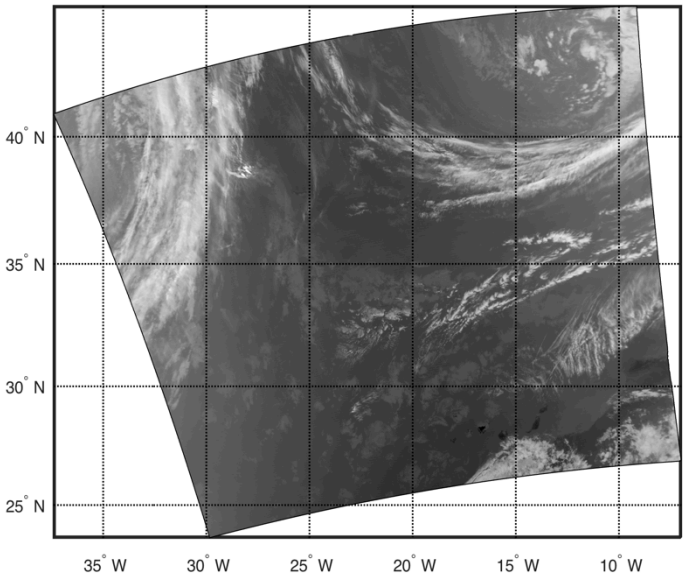
VIIRS Constructed 13.3-μm Channel



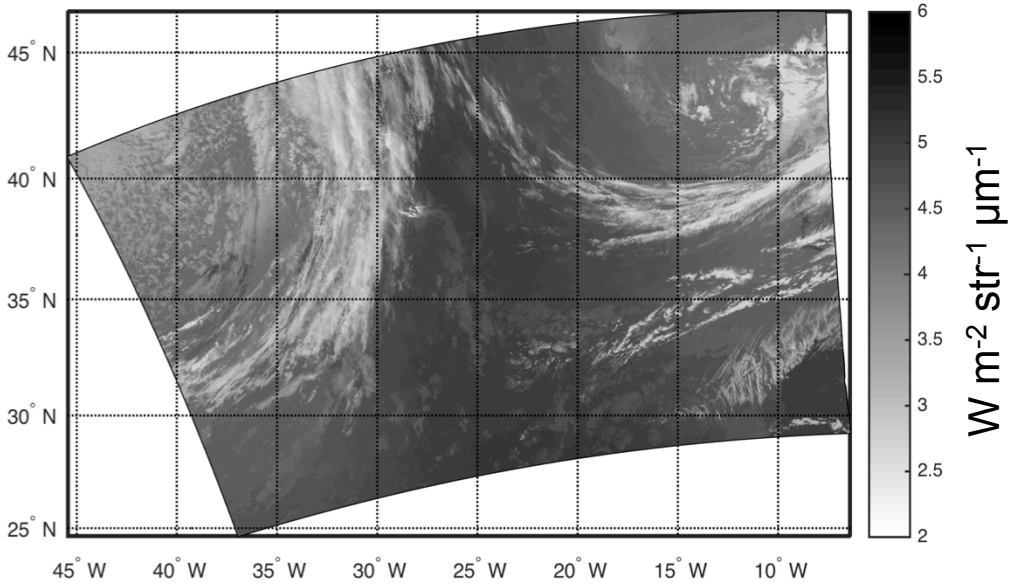
Comparison of MODIS to VIIRS 13.3-μm Radiances

April 17, 2015

MODIS



VIIRS



1435 UTC

1440 UTC

About the statistical construction approach

Pros:

- No striping, noise, or other artifacts
- Response function same as for MODIS-Aqua
- Hyperspectral IR data are well calibrated
- Do not have to account for gaps between sounder FOVs

Cons:

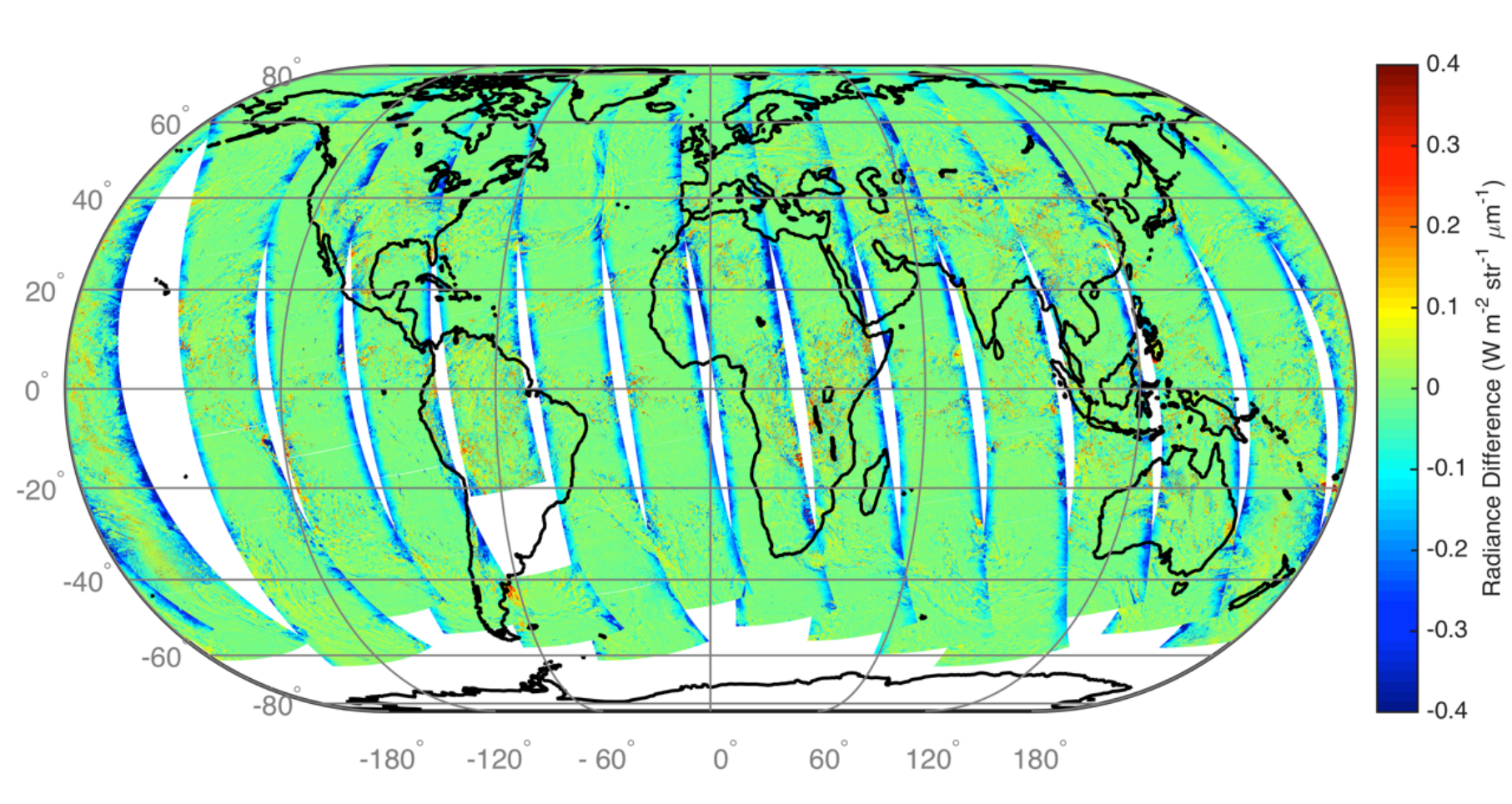
- Radiance differences increase outside of sounder swath
- Requires aligning imager and sounder granules

Radiance differences are about 1-2% of the total (~1˚K/typical scene)

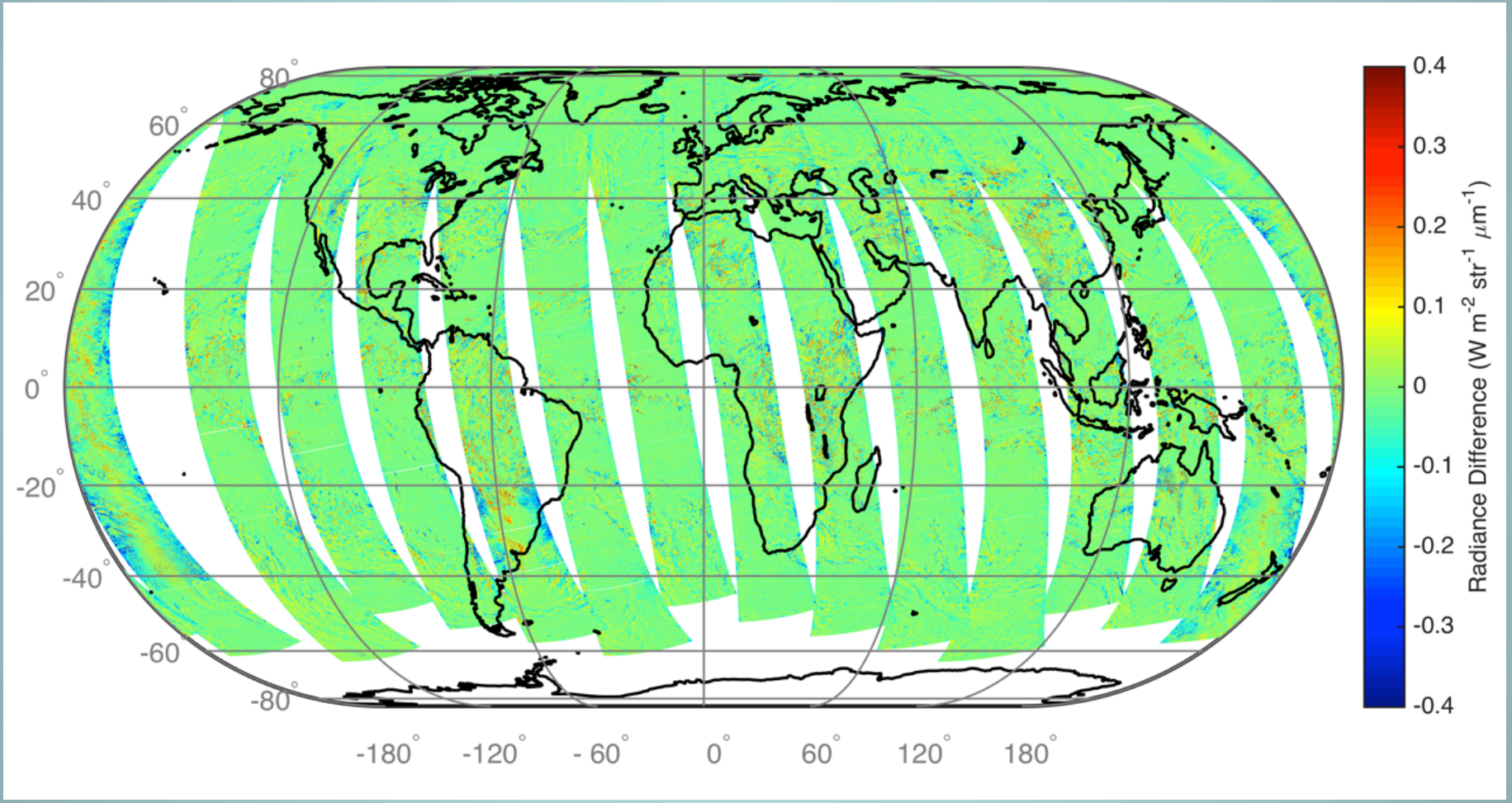
Note: this approach works only for the 13.3-μm channel – it can not be used to construct any of the IR water vapor channels or a different 15-μm CO_2 channel.

Question: how does this approach work with global MODIS data?

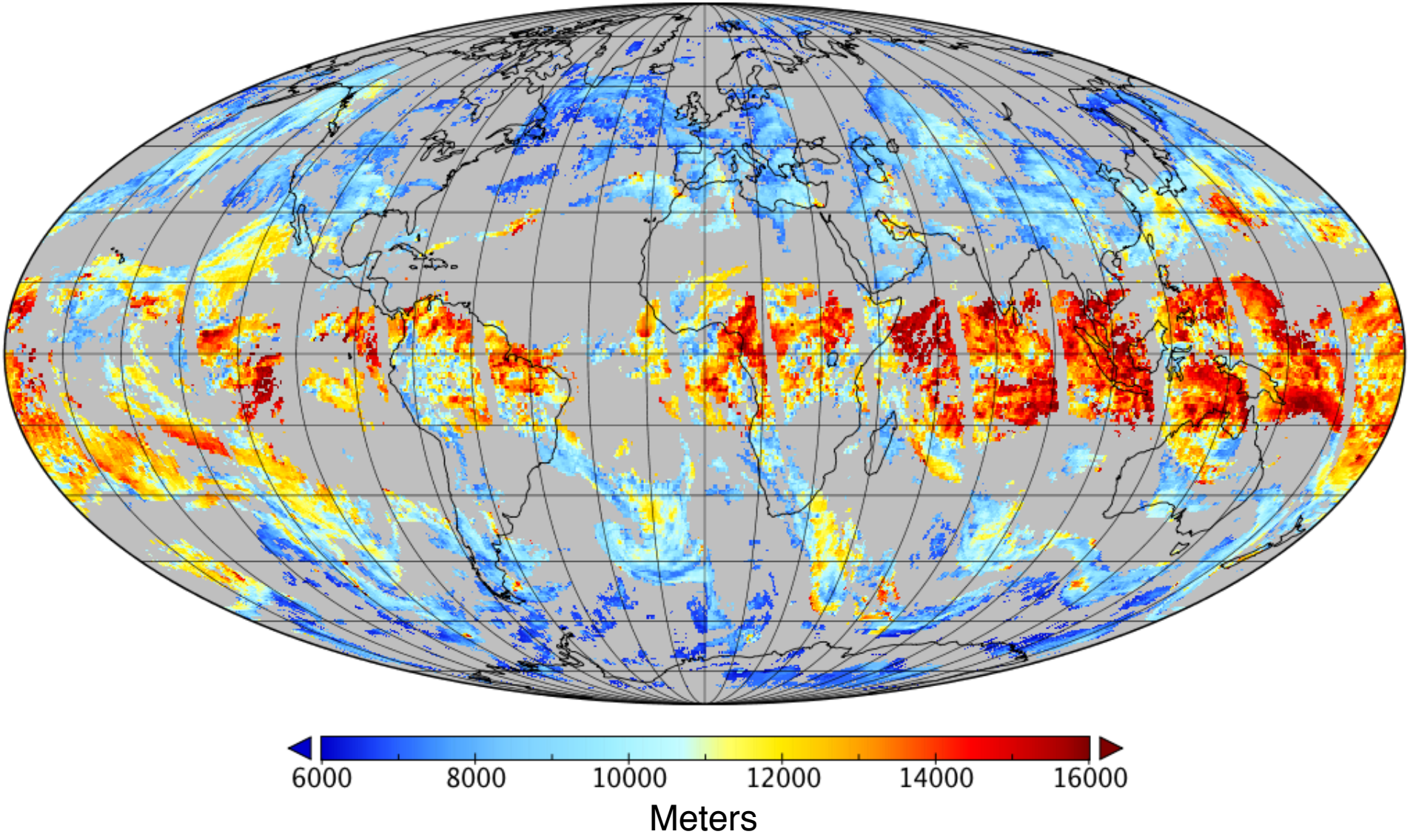
Daytime for April 17, 2015
(Real-Constructed) MODIS 13.3-µm Radiance Differences
Over all Scan Angles



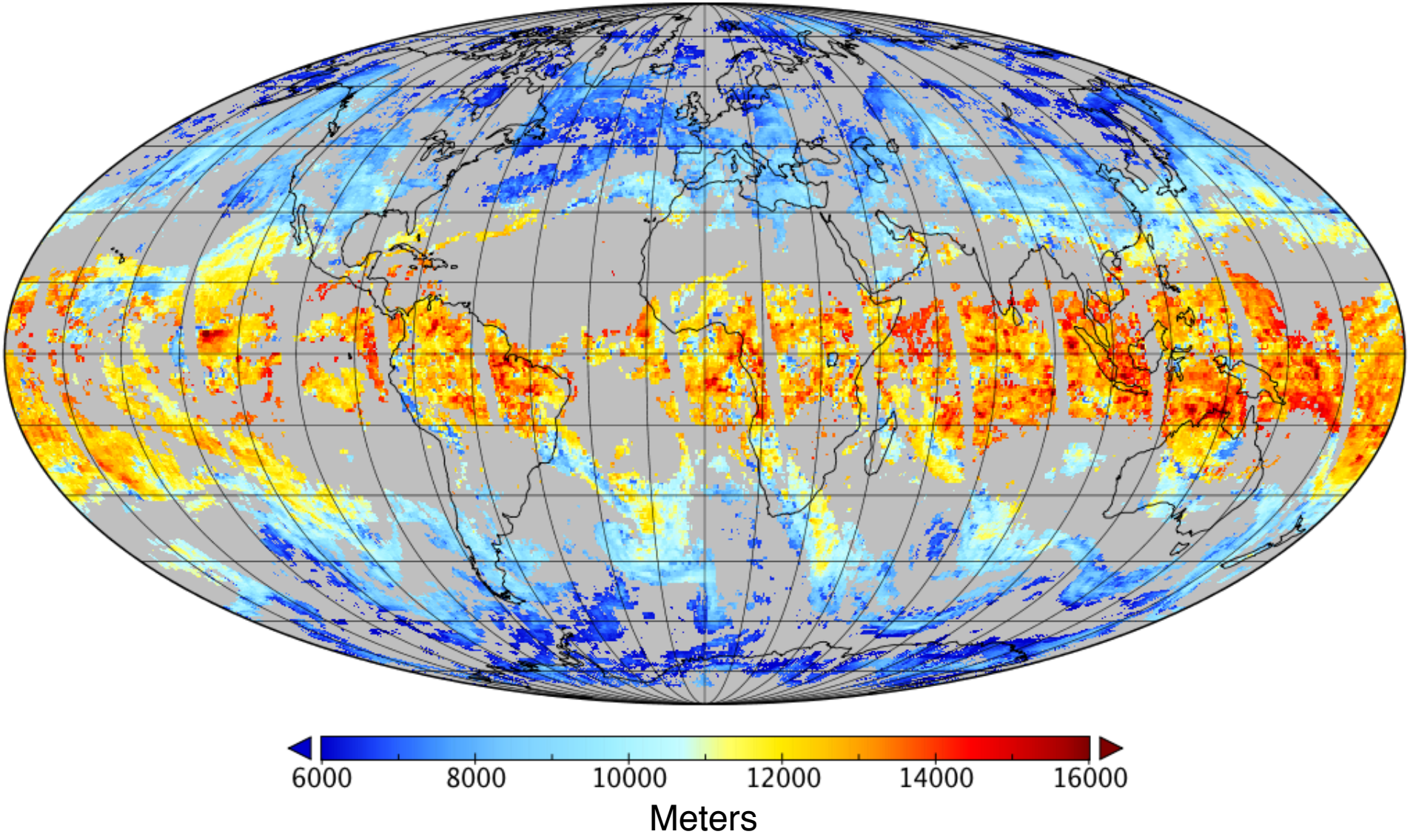
Daytime for April 17, 2015
(Real-Constructed) MODIS 13.3-µm Radiance Differences
Swath limited to Sensor Zenith Angle ≤ 58˚



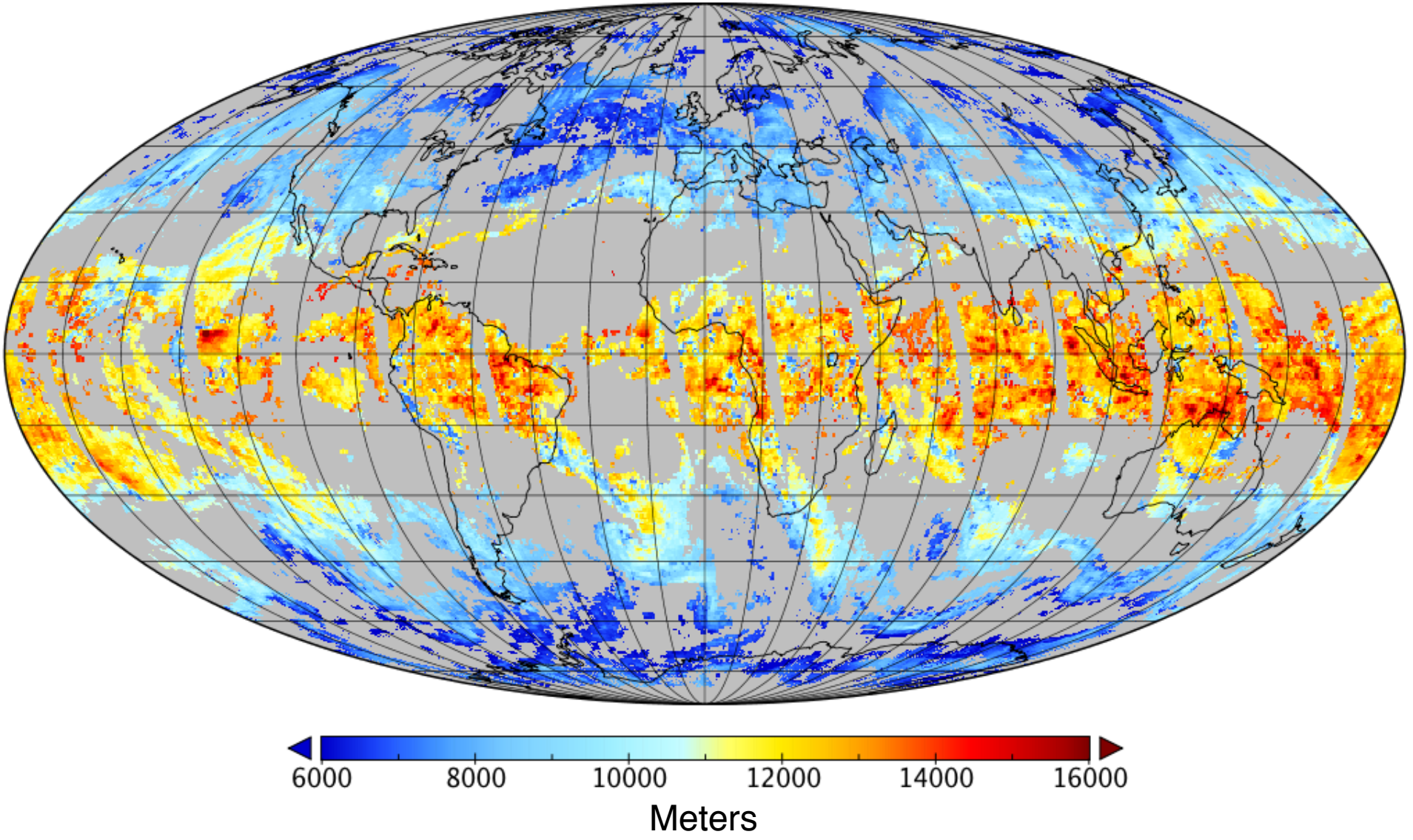
MODIS C6 High-cloud-only Heights for March 29, 2013



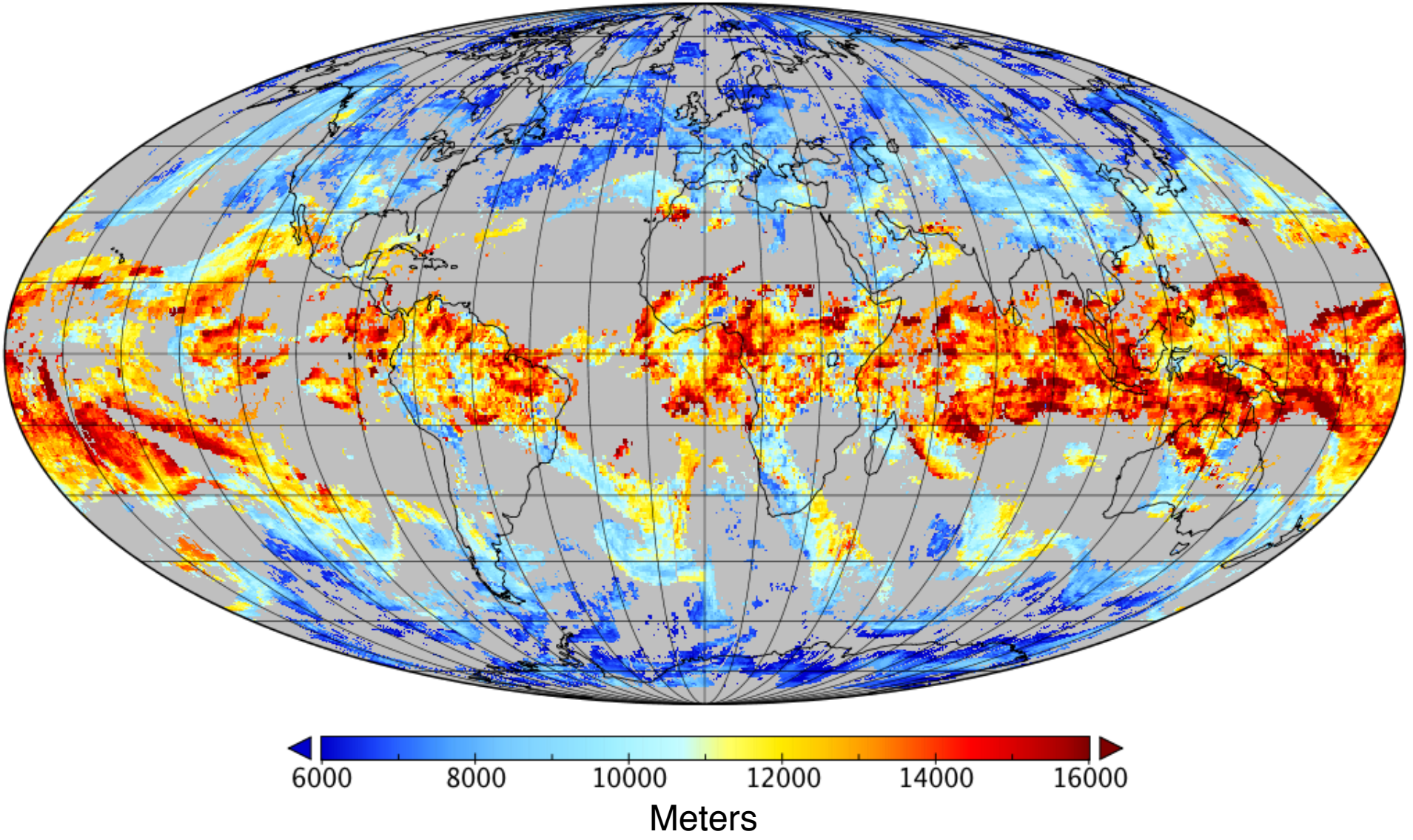
ACHA applied to MODIS
OE based on 11/12/13.3-μm bands



ACHA applied to MODIS
OE based on 11 &12-μm bands

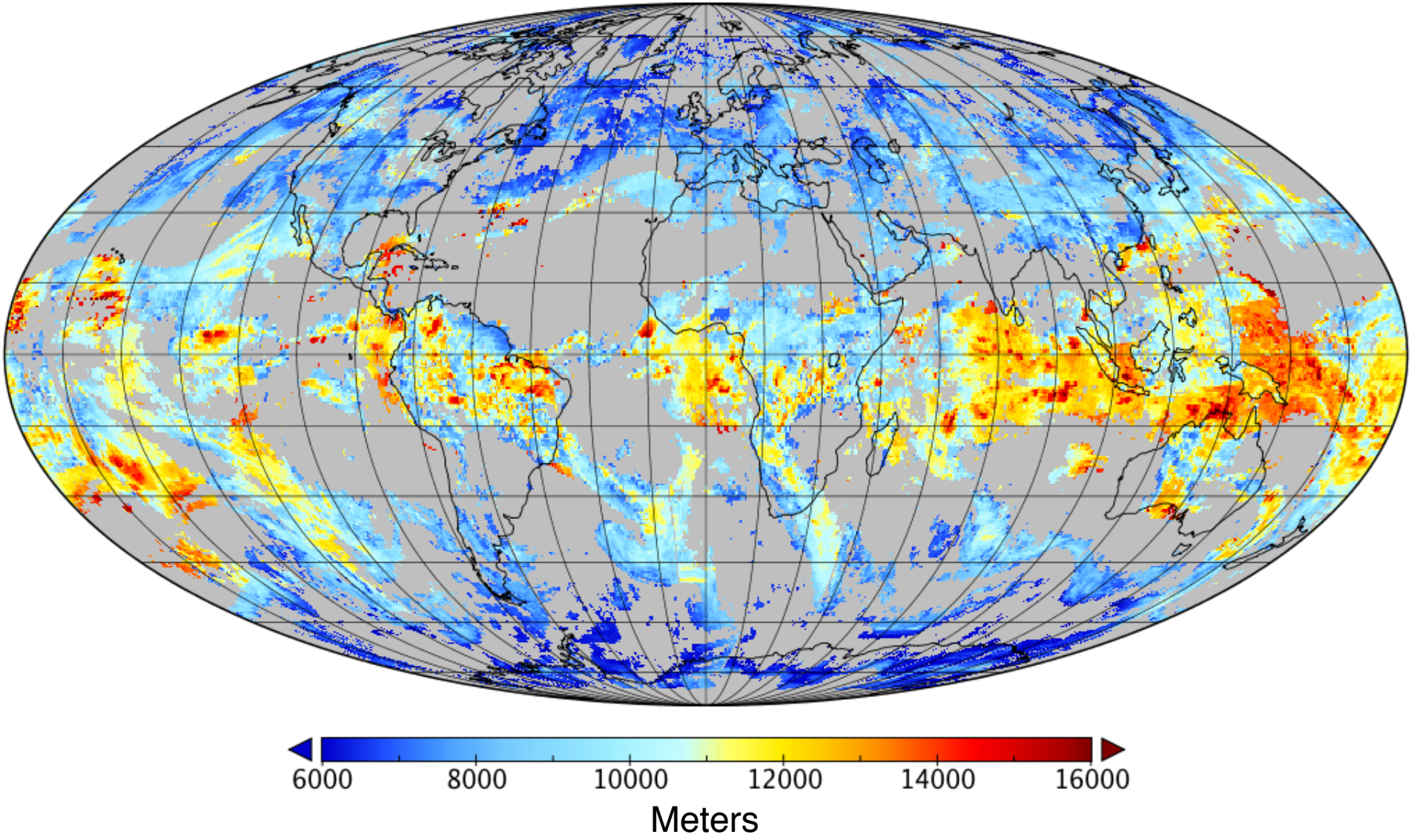


ACHA applied to VIIRS
OE based on 11 &12-μm bands



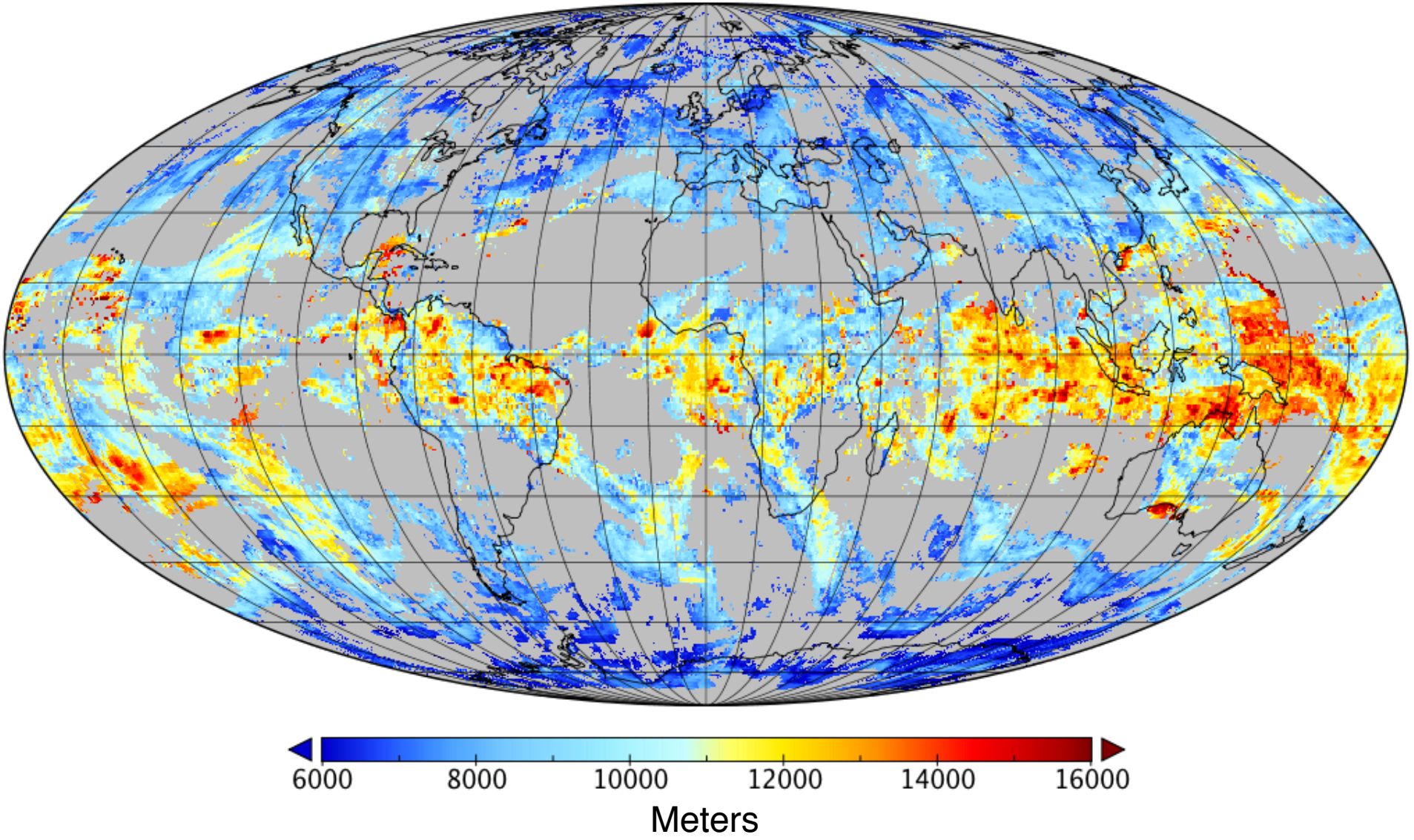
ACHA applied to VIIRS

OE based on 11/12/13.3-μm bands and Aggregate Ice Particle

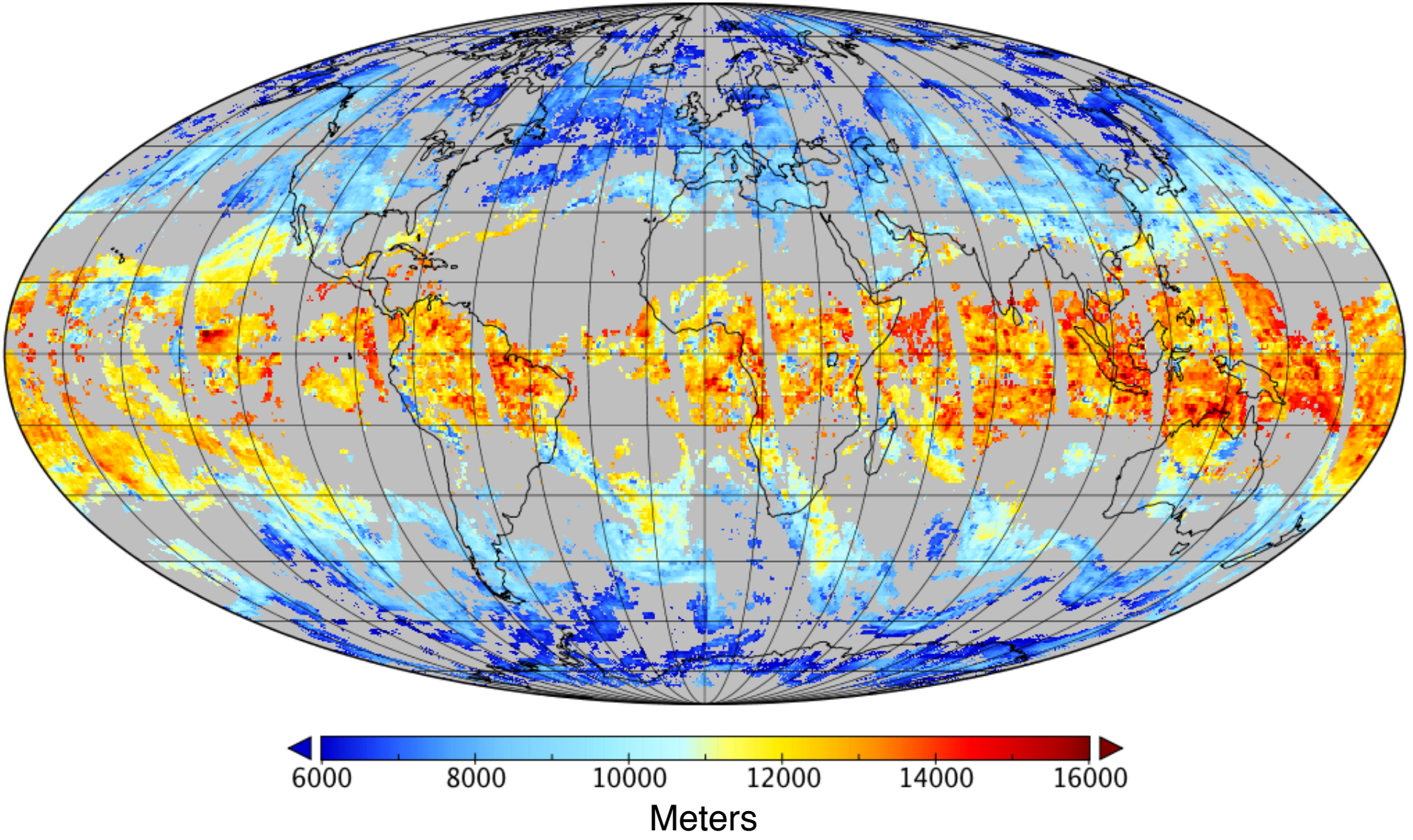


ACHA applied to VIIRS

OE based on 11/12/13.3-μm bands and Empirical Ice Model



ACHA applied to MODIS
OE based on 11/12/13.3-μm bands



In summary

Cloud product continuity assumes the ability to demonstrate that there is consistency over space and time in products from different sensors and teams…even between different versions by the same team. Several issues in the cloud climate record are highlighted by the ICWG for mitigation.

Our approach fuses data from two sensors (imager + sounder) to build a high spatial resolution 13.3-μm band.

There are differences between MODIS C6 (physical retrieval) and OE CTHs, and also between VIIRS OE and MODIS OE – time to roll up our shirtsleeves.

Suggest applying eventual VIIRS OE approach to the MODIS Terra/Aqua record to arrive at a continuity CTH product. Note that this would likely be a separate effort from the current Collection process.

Atmosphere Team Breakout Session

Atmosphere SIPS summary

Several PI talks

PI summaries

Discussion of issues (we'll get through as many as possible)

a. request for product descriptions
b. develop VIIRS L1B analog of the MYD02SSH (5-km sub-sampled data)
c. MODIS Atmosphere 6.1 reprocessing discussion (impact of L1B changes, etc)
d. VIIRS and CrIS 6-min Level 1b concerns
e. missing or additional ancillary data requests
f. Level 3 plans
g. ATBD documentation
h. process for SIPS product transfer to LAADS
i. product validation